DOE/NASA CONTRACTOR REPORT

DOE NASA CR-161094

OWENS-ILLINOIS SUBSYSTEM DESIGN PACKAGE FOR THE SEC-601 AIR-COOLED SOLAR COLLECTOR

Prepared by

Owens-Illinois
P. O. Box 1035
Toledo, Ohio 43666

Under Contract NAS8-32259 with

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy

U.S. Department of Energy

Solar Energy

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OWENS-ILLINOIS
AIR COOLED THERMAL
SOLAR COLLECTOR

SUBSYSTEM PERFORMANCE SPECIFICATION
SHC-3060
Dated 8/11/73

Spec. No. SHC-3060
Revision 4
Date June 15, 1978

Subsystem Performance Specification
SUNPAK™ Model SEC-601
Air Cooled Solar Thermal Collector

1.0 This performance specification establishes the requirements for the design and performance of the air cooled collector subsystem for use With solar combined heating and cooling systems. It designates the Interim Performance Criteria applicable to this collector subsystem.

2.0 The document applicable to this performance specification is the Interim Performance Criteria for Commercial Solar Heating and Combined Heating/ Cooling Systems and Facilities, Document N. 98M10001, Revision Basic, date February 28, 1975. George C. Marshall Space Flight Center, National Aeronautics and Space Administration.

3.0 All of the applicable Interim Performance Criteria for Commercial Subsystems as outlined in Table II so indicated are applicable after completion of the development and testing of the air cooled collector subsystem as outlined in the Statement of Work.

4.0 No deviations from the Interim Performance Criteria are proposed.

5.0 No Government furnished property will be installed in the air cooled collector subsystem.

6.0 No specific requirements have been directed by the Contracting Officer.

7.0 Preliminary performance and installation specifications for the air cooled collector subsystem are attached.

SUBSYSTEM PERFORMANCE SPECIFICATION
OWENS-ILLINOIS

8.0 Warranty - Contractor warrants for a period of five years that the solar collector material will be free of defects in quality and workmanship. Warranty is limited to shipping replacement parts prepaid which in the contractor's opinion are required to correct such defects. No field labor is included, and in no event shall Contractor be liable for special or consequential damages.

TABLE II

SPECIFICATION NO. SHC-3060
REVISION 3
DATE June 27, 1977

COMMERCIAL SUBSYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

APPLICATION

A – APPLICABLE TO SYSTEMS INDICATED
NA – NOT APPLICABLE

TYPE SYSTEMS

H – HEATING
HC – HEATING AND COOLING
HW – HOT WATER

COMMERCIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS			COMMERCIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW		H	HC	HW
1.1 H and HC System Performance	NA	NA	NA	1.6 Energy Transport	NA	NA	NA
1.1.1 Heating Design Temperature	NA	NA	NA	1.6.1 Thermal Losses and Electrical Power	NA	NA	NA
1.1.2 Cooling Design Temperature	NA	NA	NA	1.7 Control	NA	NA	NA
1.1.3 Relative Humidity	NA	NA	NA	1.7.1 Installation and Maintenance	NA	NA	NA
1.1.4 Solar Contribution	NA	NA	NA	1.7.2 Manual Adjustment	NA	NA	NA
1.2 HW System/Subsystem Performance	NA	NA	NA	1.7.3 Inhabited Space Temperature Control	NA	NA	NA
1.2.1 Draw and Temperature Design Output	NA	NA	NA	1.7.4 Hot Water Temperature	NA	NA	NA
1.2.2 Non-Tap Temperature Design Output	NA	NA	NA	1.8 Auxiliary Energy	NA	NA	NA
1.2.3 Solar Contribution	NA	NA	NA	1.8.1 Design Heat Loads	NA	NA	NA
1.3 Collector Performance	A	A	A	1.8.2 Design Cooling Loads	NA	NA	NA
1.3.1 Collector Efficiency	A	A	A	1.8.3 Impairment of Operation	NA	NA	NA
1.4 Thermal Storage Performance	NA	NA	NA	2.1 System Design Conditions	A	A	A
1.4.1 Storage Capacity and Rate	NA	NA	NA	2.1.1 Equipment Capabilities	A	A	A
1.5 Habitability of Occupied Spaces	NA	NA	NA	2.1.2 Noise or Erosion-Corrosion	A	A	A
1.5.1 Heat or Humidity Transfer Effects	NA	NA	NA	2.1.3 Operating Conditions	A	A	A
				2.1.4 Fluid Flow in Collectors	A	A	A
				2.1.5 Entrapped Air	NA	NA	NA
				2.1.6 Thermal Expansion of Fluids	NA	NA	NA
				2.1.7 Pressure Drops	A	A	A

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COMMERCIAL SUBSYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

SHEET 2 OF 6

APPLICATION

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COMMERCIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS			COMMERCIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW		H	HC	HW
2.1.8 Condensate Removal	NA	NA	NA	2.6.2 Air Quality	A	A	A
2.2 Mechanical Stresses	A	A	A	2.6.3 Fluid Treatment	NA	NA	NA
2.2.1 Vibration Stress Levels	A	A	A	2.6.4 Freezing Protection	NA	NA	NA
2.2.2 Vibration from Moving Parts	A	A	A	2.7 Piping Supports	NA	NA	NA
2.2.3 Water Hammer	NA	NA	NA	2.7.1 Applicable Plumbing Standards	NA	NA	NA
2.2.4 Vacuum Relief Protection	A	A	A	2.8 Excessive Pressure and Temperature Protection	NA	NA	NA
2.2.5 Thermal Changes	A	A	A	2.8.1 Relief Valves and Vents	NA	NA	NA
2.2.6 Flexible Joints	A	A	A	3.1 Structural Design Basis	A	A	A
2.3 Leakage Prevention	A	A	A	3.1.1 Service Loads	A	A	A
2.3.1 Pressure Test: Non-Potable Fluids	A	A	A	3.2 Failure Loads and Load Capacity	A	A	A
2.3.2 Pressure Test: Potable Water	A	A	A	3.2.1 Ultimate Load Combinations	A	A	A
2.3.3 Air Transport System	A	A	A	3.2.2 Ice Loads	A	A	A
2.4 Collector Adjustments	A	A	A	3.2.3 Vehicular Loads	NA	NA	NA
2.4.1 Orientation and Tilt	A	A	A	3.2.4 Load Capacity	A	A	A
2.4.2 Mutual Shadowing	A	A	A	3.3 Damage Control	A	A	A
2.5 Subsystem Isolation	NA	NA	NA	3.3.1 Resistance to Damage	A	A	A
2.5.1 Shutdown in Multi-unit Facilities	NA	NA	NA	3.4 Cyclic Loads	A	A	A
2.6 Heat Transfer Fluid Quality	A	A	A	3.4.1 Deflection Limitations	A	A	A
				3.5 Cutting of Structural Elements	NA	NA	NA
				3.5.1 Design Provisions	NA	NA	NA

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SPECIFICATION NO. SHC-3060
REVISION 3
DATE June 27, 1977

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	H	HC	HW		H	HC	HW
3.6 Creep and Residual Deflection	A	A	A	4.3.2 Penetrations Through Fire-Rated Assemblies	NA	NA	NA
3.6.1 Deflection Limitations	A	A	A	4.4 Toxic and Flammable Fluids	NA	NA	NA
3.7 Hail Resistance	A	A	A	4.4.1 Provision of Catch Basins	NA	NA	NA
3.7.1 Hail Size and Loading	A	A	A	4.4.2 Detection of Toxic and Flammable Fluids	NA	NA	NA
3.8 Constraint Loads	A	A	A	4.5 Safety Under Emergency Conditions	NA	NA	NA
3.8.1 Foundation Settlement	A	A	A	4.5.1 Emergency Egress and Access	NA	NA	NA
3.9 Ponding Conditions	A	A	A	4.5.2 Identification and Location of Controls	NA	NA	NA
3.9.1 Design Provisions	A	A	A	4.6 Protection of Water and Circulated Air	A	A	A
4.1 Plumbing and Electrical Installation	NA	NA	NA	4.6.1 Contamination by Materials	NA	NA	NA
4.1.1 Plumbing Codes and Standards	NA	NA	NA	4.6.2 Separation of Circulation Loops	NA	NA	NA
4.1.2 Electrical Codes and Standards	NA	NA	NA	4.6.3 Backflow Prevention	NA	NA	NA
4.2 Fail-Safe Controls	A	A	A	4.6.4 Growth of Fungi	A	A	A
4.2.1 System Failure Prevention	A	A	A	4.7 Excessive Surface Temperature	A	A	A
4.2.2 Automatic Pressure Relief Valves	NA	NA	NA	4.7.1 Protection from Heated Components	A	A	A
4.3 Fire Safety	A	A	A	5.1 Effects of External Environment	A	A	A
4.3.1 Applicable Fire Standards	A	A	A	5.1.1 Solar Degradation	A	A	A
				5.1.2 Soil Corrosion	NA	NA	NA
				5.1.3 Airborne Pollutants	A	A	A

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	H	HC	HW		H	HC	HW
5.1.4 Dirt Retention on Cover Plate Surfaces	A	A	A	5.4 Components Involving Moving Parts	NA	NA	NA
5.1.5 Abrasive Wear	A	A	A	5.4.1 Wear and Fatigue	NA	NA	NA
5.1.6 Fluttering by Wind	A	A	A	6.1 Accessibility for Maintenance and Servicing	A	A	A
5.2 Temperature and Pressure Resistance	A	A	A	6.1.1 Access for System Maintenance	A	A	A
5.2.1 Thermal Degradation	A	A	A	6.1.2 Access for System Monitoring	A	A	A
5.2.2 Deterioration of Heat Transfer Fluids	NA	NA	NA	6.1.3 Draining and Filling of Liquids	NA	NA	NA
5.2.3 Thermal Cycling Stresses	A	A	A	6.1.4 Flushing of Liquid Subsystems	NA	NA	NA
5.2.4 Leakage	NA	NA	NA	6.1.5 Filters	NA	NA	NA
5.2.5 Deterioration of Gaskets and Sealants	A	A	A	6.1.6 Water Shutoff	NA	NA	NA
5.2.6 Transmission of Losses Due to Out-glassing	A	A	A	6.2 Installation, Operation and Maintenance Manual	A	A	A
5.3 Chemical Compatibility of Components	A	A	A	6.2.1 Installation Instructions	A	A	A
5.3.1 Materials/Transfer Fluid Compatibility	A	A	A	6.2.2 Maintenance and Operating Instructions	A	A	A
5.3.2 Corrosion of Dissimilar Materials	A	A	A	6.2.3 Maintenance Plan	A	A	A
5.3.3 Corrosion by Leachable Substances	NA	NA	NA	6.2.4 Replacement Parts	A	A	A
5.3.4 Effects of Decomposition Products	A	A	A	6.3 Repair and Service Personnel	A	A	A
				6.3.1 Servicing of H and HC Systems	A	A	A
				6.3.2 Servicing of HW Systems	A	A	A
				7.1 Design	NA	NA	NA

SPECIFICATION NO SHC-3060
REVISION
DATE October 1, 1976

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	H	HC	HW		H	HC	HW
7.1.1 Design-Habitable Facilities	NA	NA	NA	8.1.3 Sensor Location	NA	NA	NA
7.1.2 Esthetics	NA	NA	NA	8.2 Mechanical and Electrical Functioning of Facility and Site	NA	NA	NA
7.1.3 Materials							
7.1.4 Passive Use of Solar Energy	NA	NA	NA	8.2.1 Exhaust and Venting	NA	NA	NA
				8.2.2 Utilities	NA	NA	NA
7.2 Adequate Space	NA	NA	NA	8.3 Mechanical and Electrical Functioning of Connections	NA	NA	NA
7.2.1 Solar Collector	NA	NA	NA				
7.2.2 Storage	NA	NA	NA				
7.2.3 Interface Between Facility and H and HC Systems				8.3.1 Plumbing Connections	NA	NA	NA
				8.3.2 Electrical Connections	NA	NA	NA
				8.3.3 Lightning Protection	NA	NA	NA
7.2.4 Portability	NA	NA	NA				
7.3 Functioning of Facilities and Sites	NA	NA	NA	9.1 Structural Integrity of H, HC and HW Systems	NA	NA	NA
7.3.1 Space Use	NA	NA	NA	9.1.1 Movement of Adjacent Structures	NA	NA	NA
7.3.2 Shading	NA	NA	NA				
7.3.3 Impact on Environment	NA	NA	NA	9.2 Structural Integrity of Facilities	NA	NA	NA
7.3.4 View	NA	NA	NA	9.2.1 Loads	NA	NA	NA
7.4 Compatibility with Conventional Systems	NA	NA	NA	9.2.2 Penetration of Structural Members	NA	NA	NA
				9.3 Structural Connections	NA	NA	NA
7.4.1 Utility Compatibility	NA	NA	NA	9.3.1 Structural Connections	NA	NA	NA
				9.3.2 Brittle Components	NA	NA	NA
8.1 Interference with Mechanical Operation	NA	NA	NA	9.3.3 Strength and Stiffness	NA	NA	NA
				10.1 Safety of Facility and Site	NA	NA	NA
8.1.1 Blockage of Solar Solar Components	NA	NA	NA	10.1.1 Fire	NA	NA	NA
8.1.2 Shading of Collectors	NA	NA	NA	10.1.2 Accidents	NA	NA	NA

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	H	HC	HW		H	HC	HW
11.1 Durability and Reliability of H, HC and HW Systems	NA	NA	NA	12.3.1 Accessibility	NA	NA	NA
11.1.1 Vegetation	NA	NA	NA	13.1 Visual Characteristics of Facility and Site	NA	NA	NA
11.2 Durability and Reliability of Facilities and Sites	NA	NA	NA	13.1.1 Facility	NA	NA	NA
11.2.1 Chemical Corrosion	A	A	A	13.1.2 Neighborhood	NA	NA	NA
11.2.2 Heat and Moisture	A	A	A				
11.2.3 Exterior Penetrations	NA	NA	NA				
11.3 Durability and Reliability of Connections	A	A	A				
11.3.1 Material Compatibility	A	A	A				
12.1 Maintainability of H, HC and HW Systems	NA	NA	NA				
12.1.1 Accessibility	NA	NA	NA				
12.1.2 Misuse	NA	NA	NA				
12.1.3 Permanent Maintenance Accessories	NA	NA	NA				
12.2 Maintainability of Facility and Site	NA	NA	NA				
12.2.1 Accessibility	NA	NA	NA				
12.2.2 Ice Dams	NA	NA	NA				
12.3 Connections	NA	NA	NA				

Air Cooled Collector Performance

The Owens-Illinois Solar Collector Model SEC 601 will collect a minimum of 1050 Btu/ft.^{2} day of energy at an inlet fluid temperature equal to or less than 160° and an air flow rate equal to or greater than 2 SCFM/ft.^{2} under the following conditions:

Tilt Angle: Equal to latitude; Azimuth Angle: 0°

Anbient Temperature: 30°F

Wind Velocity: 0-5000 ft./min.

Date: March, September 21

Daily Solar Flux in the Plane of the Collector Surface: 2330 Btu/ft.^{2} day.

Longitude: Any: Latitude: Any

The Solar Collector will collect a minimum of 900 Btu/ft.^{2} day of energy at an inlet fluid temperature equal to or less than 220°F and an air flow rate equal to or greater than 2 SCFM/ft.^{2} under the following conditions:

Tilt Angle: Equal to latitude; Azimuth Angle: 0°

Ambient Temperature: 50°F

Wind Velocity: 0-5000 ft./min.

Date: Match, September 21

Daily Solar Flux in the Plane of Collector Surface: 2330 Btu/ft.^{2} day.

Longitude: Any; Latitude: Any

$$n = \frac{\bar{M} C_p (\bar{T}_o - \bar{T}_i)}{A_c \bar{I}}$$

$\bar{T}_o$ = collector transport media hourly average outlet temperature (°F)

$\bar{T}_i$ = collector transport media hourly average inlet temperature (°F)

$\bar{T}_a$ = average hourly ambient temperature (°F)

$\bar{M}$ = transport media hourly average flow rate (lb./hr.)

C_p = specific heat of transport media (Btu/lb.°F)

A_c = area of collector (sq. ft.) (based on aperture area)

$\bar{I}$ = hourly average total solar insolation in the collector plane (Btu/hr. - sq. ft.)

NOTE: The data utilized to obtain the hourly averages must be for at least one full day.

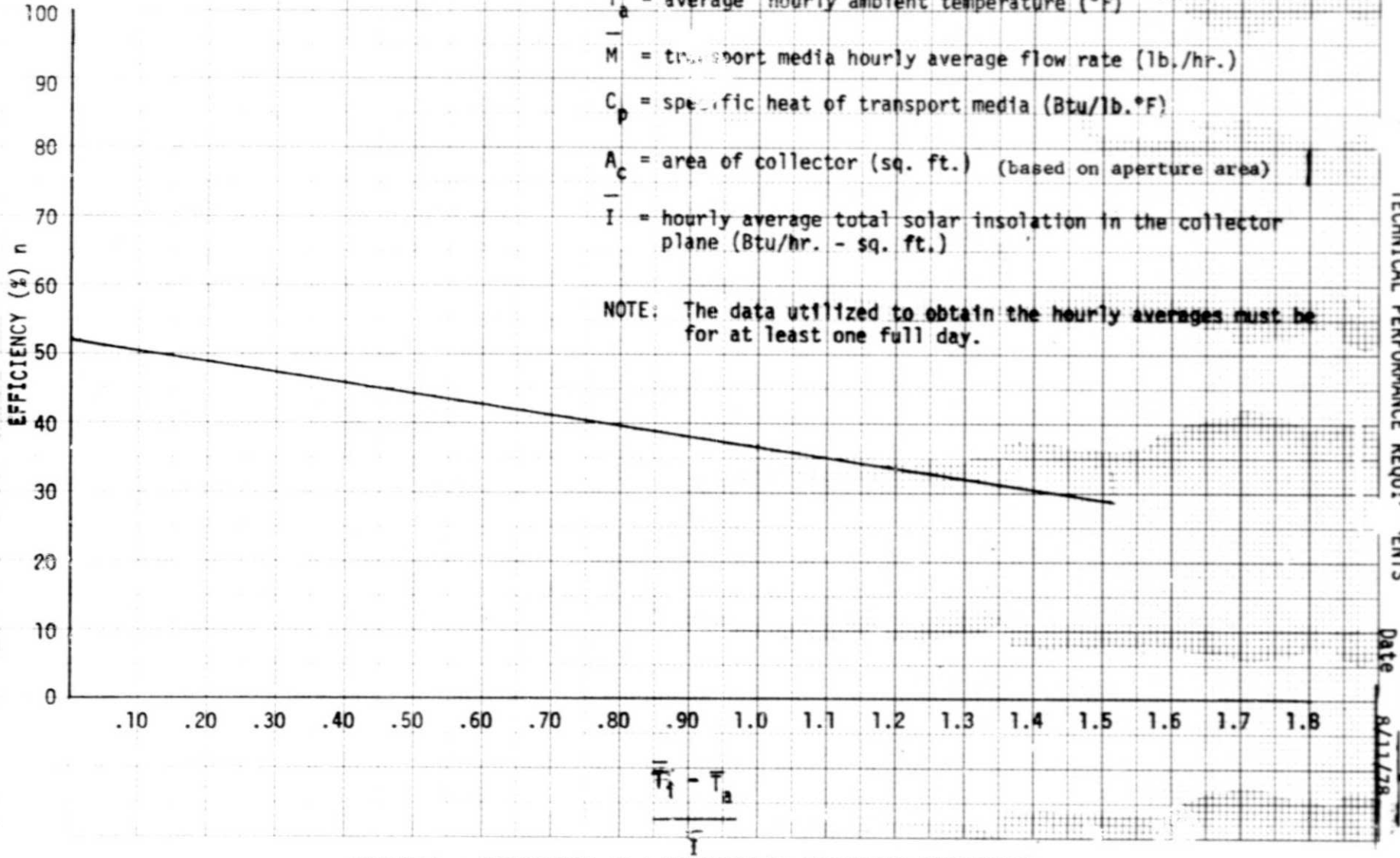


FIGURE 1 - EFFICIENCY AS A FUNCTION OF OPERATING CONDITIONS
PERFORMANCE MUST BE ABOVE LINE

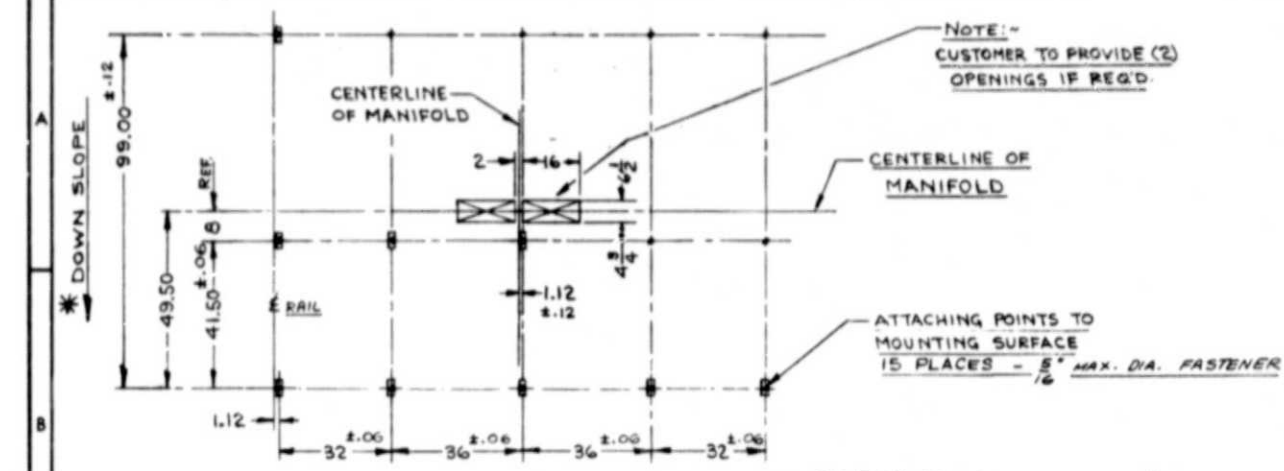
ASSEMBLY AND INSTALLATION DRAWINGS

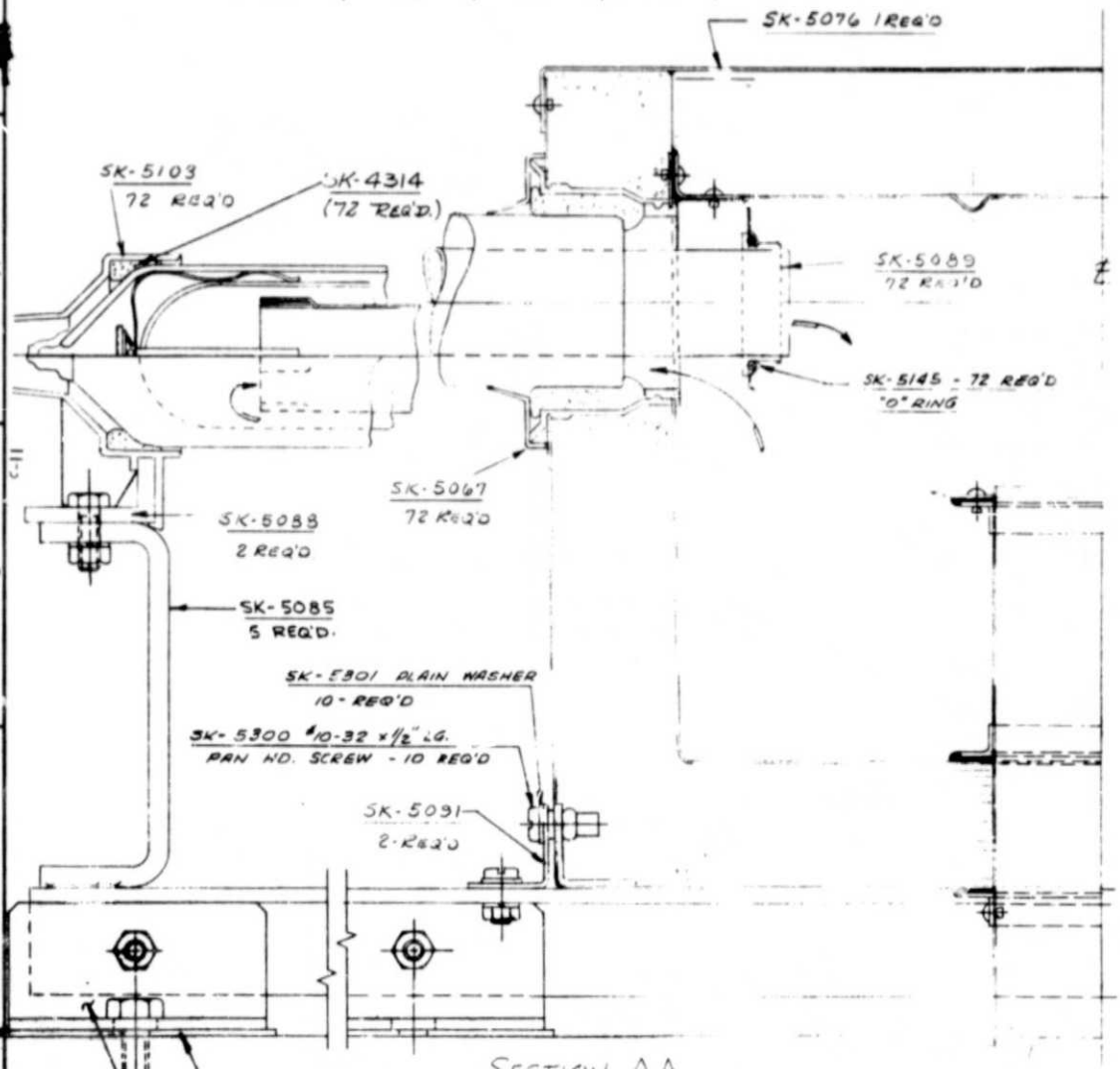
SK-5076-Manifold Assembly, Complete

SK-5075-Solar Collector Installation

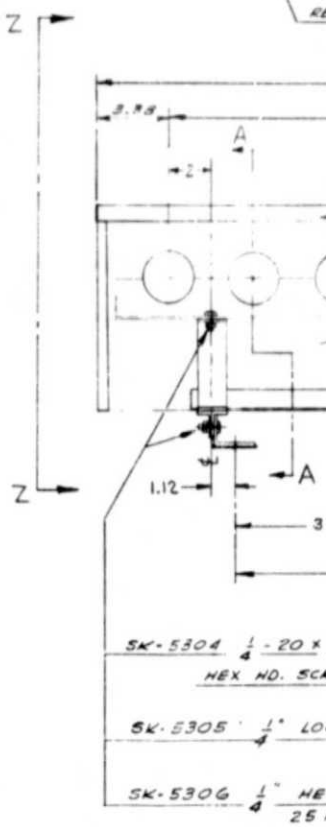
Note: Drawings of the detail parts called out on each of the above drawings may be obtained from Owens-Illinois, P.O. Box 1035, Toledo, Ohio 43666.

☆ U.S. GOVERNMENT PRINTING OFFICE 1979—640-247/184 REGION NO. 4





SECTION AA
CROSSECTION ELEVATION SCALE 1:1



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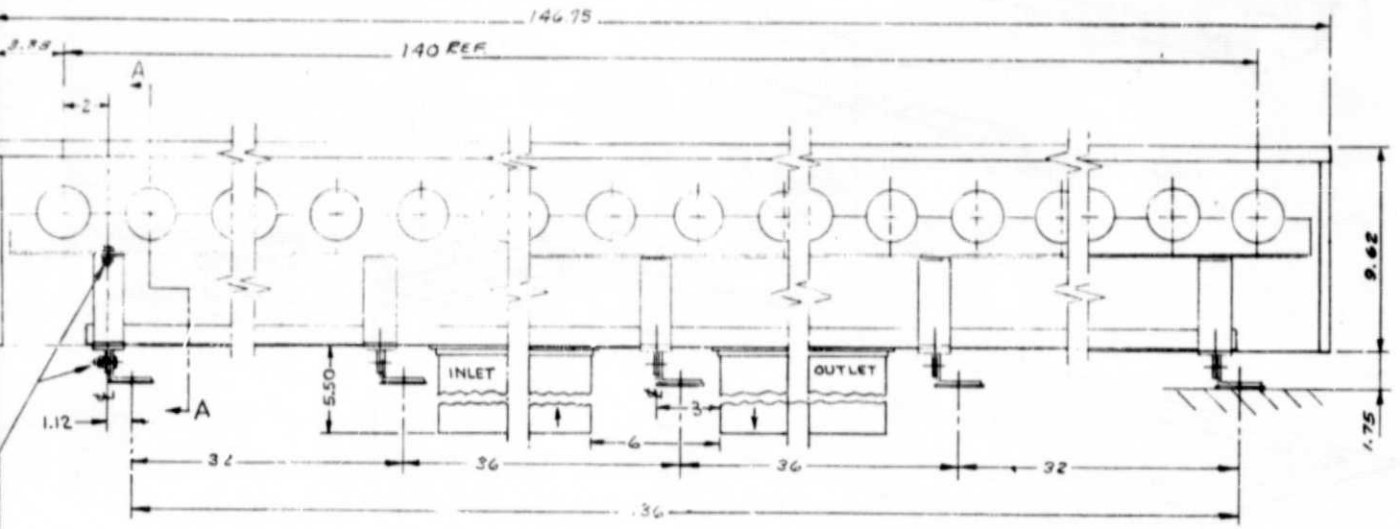
SK-5075

VIEW Z-Z SCALE .25:1



SIDE ELEVATION SCALE .25:1

SK-5304 1/4-20 x 3/4" LG. HEX HD. SCREW - 25 REQ'D

SK-5305 1/4" LOCKWASHER 25 REQ'D

SK-5306 1/4" HEX NUT 25 REQ'D

CHG.	DESCRIPTION	BY	DATE	MF
B	RELEASED	R.M.	10/31	RW
A	ROOF MTGS REVISED	A.R.	11/17/77	

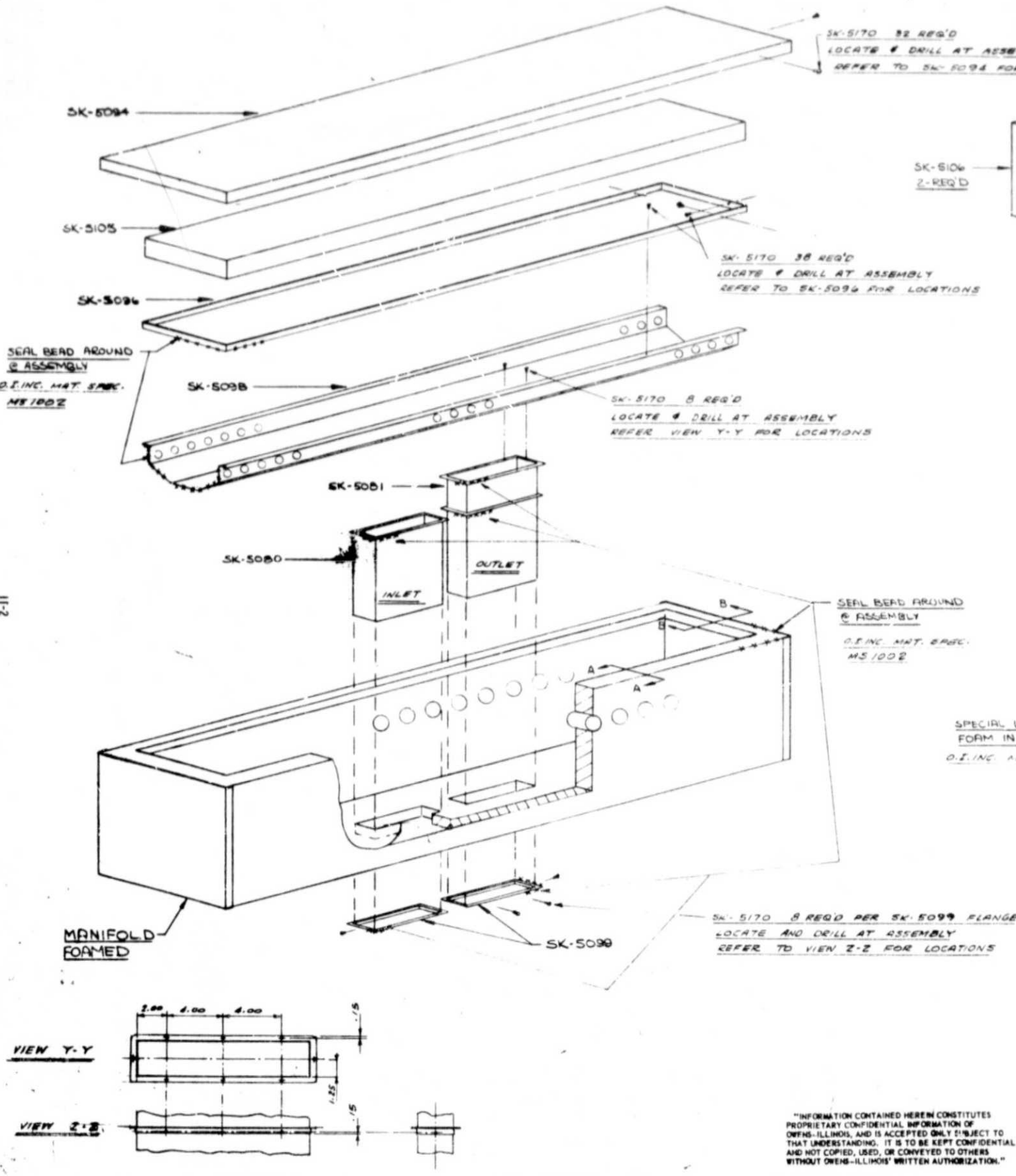
USED ON ASSEMBLY NO.

TOLERANCE UNLESS OTHERWISE NOTED	2 PLACE DEC. ±	DEFINITION OF SYMBOLS (Total Indicator Reading)	SCALE NOTED	INCHES	OWENS-ILLINOIS CORPORATE TECHNOLOGY TOLEDO, OHIO
	3 PLACE DEC. ±		MATERIAL		
	ANGLES ±	CONCENTRICITY	HEAT TREAT		
CORNERS AND/OR EDGES BROKEN	OUTSIDE RAD. MAX.	ROUNDNESS	CASE DEPTH		
	INSIDE RAD. MAX.	FLATNESS	HARDNESS		
UNLESS SPECIFIED, MACHINED SURFACE ROUGHNESS NOT TO EXCEED √	RADII UNLESS OTHERWISE NOTED	SYMMETRY	SUR. TREAT		
		PARALLEL			
		PERPENDICULAR			

PROJECT NO. C-2370 DES'D 9/28/77 RA
DR'N / /
CK'D / /
SOLAR COLLECTOR MODEL SEC-601
NUMBER SK-5075 D
SHEET 1 OF 1 SIZE

A-1

2 FOLDOUT FRAME



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SK-5070 32 REQ'D
LOCATE & DRILL AT ASSEMBLY
OFFSET TO SK-5094 FOR LOCATIONS

SK-5078
WELDED

SK-5106
2 REQ'D

SK-5104

32 REQ'D
& DRILL AT ASSEMBLY
TO SK-5094 FOR LOCATIONS

SK-5077
WELDED

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SEMBLY
E LOCATIONS

SEAL BEAD AROUND
@ ASSEMBLY
O-RING PART SPEC:
MS-002

SK-5066
12 REQ'D

SK-5064
12 REQ'D

SPECIAL URETHANE
FOAM IN PLACE
O-RING PART SPEC: MS-001

SK-5104
BONDED TO SK-5077 & SK-5078
O-RING PART SPEC MS-002

SECTION A-A

SK-5106
REF
BOND TO SK-5078
O-RING PART SPEC:
MS-002

9.62 FOAM

SECTION B-B

8 REQ'D PER SK-5099 FLANGE (16 TOTAL)
AND DRILL AT ASSEMBLY
TO VIEW Z-Z FOR LOCATIONS

CHG	DESCRIPTION	BY	DATE	APP
A	RELEASED			

USED ON ASSEMBLY NO SK 5076

TOLERANCE UNLESS OTHERWISE NOTED	2 PLACE DEC. ±	DEFINITION OF SYMBOLS (Total Indicator Reading)	SCALE
	3 PLACE DEC. ±	◎ CONCENTRICITY	MATERIAL
	ANGLES ±	○ ROUNDNESS	
CORNERS AND/OR EDGES BROKEN	OUTSIDE RAD. MAX	⌓ FLATNESS	HEAT TREAT
	INSIDE RAD. MAX	⌯ SYMMETRY	CASE DEPTH
UNLESS SPECIFIED, MACHINED SURFACE ROUGHNESS NOT TO EXCEED √	RADII UNLESS OTHERWISE NOTED	∥ PARALLEL	HARDNESS
		⊥ PERPENDICULAR	SUR TREAT

OWENS-ILLINOIS
CORPORATE TECHNOLOGY
TOLEDO, OHIO

PROJECT NO. C-2370
DES'D
DR'N 8/16/77
CK'D 8/16/77

MANIFOLD ASSEM. COMPLETE
NUMBER SK-5076
SHEET 1 OF 1
SIZE D

PRINT 2